PATENT

Docket No. 53249USA5A

SURFACE TENSION RELIEVED MOUNTING MATERIAL

Field of the Invention

The present invention relates to a mounting article for use in mounting monolithic structures for use in pollution control devices. More specifically, the present invention relates to a sheet material having reduced surface tension that is used to mount and support monoliths used in pollution control devices.

Background of the Invention

Intumescent sheet materials are typically used in pollution control devices to mount and support a fragile monolith within a housing. The monoliths are typically made of ceramic but may also be made of metal such as stainless steel. The housings are also typically made of metal and preferably are made of stainless steel. Metal housings typically have coefficients of thermal expansion that are much greater than the thermal expansion coefficients of ceramic monoliths. The intumescent sheet materials are disposed between the monolith and the housing to protect the monolith from damage and to prevent the exhaust gases from bypassing the monolith and exiting untreated. Typically, the catalysts that are supported on the monolith do not effectively treat the exhaust gases until the monolith and the catalyst reaches the optimum operating temperature. One way of reducing the time required for the monolith and catalyst to reach the optimum operating temperature is to move the catalytic converter closer to the engine, which also results in higher operating temperatures. Because of the higher operating temperatures, thicker mounting mat materials are required. The thicker mounting mats keep the housing relatively cool while maintaining a high temperature gradient across the mounting mat which is beneficial for the monolith holding performance of the mounting mat. However, the types of converter monoliths that are typically used for these applications have relatively smaller monolith cross-sections, making it difficult to

wrap the thicker mounting materials around the smaller contours of the monolith without cracking or breaking the sheet material.

Summary of the Invention

The present invention provides a mounting article having reduced or relieved surface tension for pollution control devices which utilize a monolith structure within a metal housing. The mounting article comprises a sheet material suitable for mounting a pollution control; element within a housing having major top and bottom surfaces, a thickness, a length and a width, said sheet material having at least one score-line in a surface of said sheet material. In a preferred embodiment, the sheet material has two score-lines across the width of the sheet material. In another preferred embodiment, the sheet material is an intumescent sheet material.

The present invention also provides a pollution control device comprising a housing, a pollution control element disposed within the housing, and a mounting article of the invention disposed between the pollution control element and the housing. One of the advantages of the mounting articles of the invention is that the invention allows the use of relatively thicker sheet materials in pollution control devices without undesirable cracking or breaking of the sheet material.

As used herein a "score-line" means a controlled and intended discontinuity in a surface of the sheet material which does not penetrate the entire thickness of the sheet material used to mount a pollution control element.

As used herein "intumescent sheet material" means a sheet material useful for mounting a pollution control device within a housing that contains an intumescent material that swells, foams, or expands when subjected to sufficient thermal energy.

As used herein, a "non-intumescent sheet material" means a substantially inorganic, fibrous sheet material which does not contain an intumescent material and which does not expand beyond the amount expected from the inherent coefficient of thermal expansion of the non-intumescent materials when subjected to thermal energy.

Brief Description of the Drawings

Figure 1 is perspective exploded view of a catalytic converter showing the mounting article of the present invention.

Figure 2 is another view of the catalytic converter of Figure 1 showing the mounting article of the present invention peeled away from the monolith.

Figure 3A is a plan view of an embodiment of the mounting article of the invention and Figure 3B is a front view of an oval monolith wrapped in the mounting article of Figure 3A.

Figure 4A is a plan view of an embodiment of the mounting article of the invention and Figure 4B is a front view of an oval monolith wrapped in the mounting article of Figure 4A.

Figure 5A is a plan view of an embodiment of the mounting article of the invention and Figure 5B is a front view of an oval monolith wrapped in the mounting article of Figure 5A.

Figure 6A is a plan view of a sheet material having a plurality of score-lines and Figure 6B is a front view of a round monolith wrapped in the mounting article of Figure 6A.

Figure 7A is a cross-sectional view of a sheet material having a plurality of score-lines and Figure 7B is a front view of a round monolith wrapped with the mounting article of Figure 7A.

Figure 8A is a plan view of a sheet material having a plurality of score-lines on both surfaces and Figure 8B is a front view of a round monolith wrapped in the sheet material of Figure 8A.

Figures 9 and 10 are plan views of other embodiments of the mounting article of the invention.

Figure 11 is a perspective view of a die for making an embodiment of the mounting articles of the invention.

Detailed Description of the Preferred Embodiments

Although the mounting articles of the present invention are suitable for use in a variety of pollution control devices, such as catalytic converters and diesel particulate filters, elements, or traps, their use is described herein in connection

with a catalytic converter. The description is intended to be illustrative of the use of the mounting articles of the present invention and should not be construed as limiting the use of the mounting articles to catalytic converters.

Referring to Figures 1 and 2, catalytic converter 10 comprises a metallic housing 12 with generally conical inlet 14 and outlet 16. The housing, which is also known as a can or casing, can be made from suitable materials known in the art for such use and is typically made from metal. Preferably, housing 12 is made from stainless steel. A monolithic catalytic element 18 is disposed within the housing 12 and is made from a honeycombed monolithic body of either ceramic or metal. Suitable catalytic elements, also known as monoliths, are known in the art and include those made from ceramic or metal. In this embodiment, monolith 18 is generally oval shaped in cross-section and has areas of maximum or larger radius of curvature 19 and areas of minimum or smaller radius of curvature 13. Monolith 18 is used to support the catalyst materials for the converter. A useful monolith is disclosed, for example, in U.S. RE 27,747 (Johnson). Monolith has a plurality of gas flow channels 21 therethrough. The catalyst materials coated onto the catalytic converter monoliths include those known in the art, for example, metals such as ruthenium, osmium, rhodium, iridium, nickel, palladium, and platinum and metal oxides such as vanadium pentoxide and titanium dioxide. Useful catalytic coatings are described in more detail in, for example, U.S. Patent No. 3,441,381 (Keith et al.).

For purposes of the invention, the monolith may be any shape that can be wrapped with a sheet material. Examples of such shapes include those having the cross-sectional shape of a circle, ellipse, trapezoid, square, rectangle, triangle and polygon.

Surrounding monolith 18 is surface tension relieved mounting article 20. Mounting article 20 comprises a sheet material 22 useful for mounting catalytic converters having surface discontinuities or score-lines 24 into top surface 23 of the sheet material. Top surface 23 is the surface of the sheet material that is adjacent to the housing when sheet material 22 is mounted within a catalytic converter. Bottom surface 25 is the surface of the sheet material that is adjacent to the monolith when the sheet material is mounted within a catalytic converter.

As seen more clearly in Figures 3A and 3B, score-lines 24 adjacent each end of sheet material 22 extend transversely and in parallel across the width and perpendicular to the length of the sheet material 22. Figure 3B illustrates a sheet material 22 surrounding an oval shaped monolith 18 and demonstrates how score-lines 24 relieve surface tension in the sheet. In this embodiment, score-lines 24 are preferably placed in the top surface 23 of the sheet material 22 at the point or within the area of the surface which corresponds to the smallest radius of curvature 13 of the monolith when the sheet material is wrapped around the monolith. As shown in Figure 3B, score-lines 24 provide openings 26 in the sheet material 22 that are predictable in location, depth and width. Predictable openings are advantageous because they can be taken into account when designing the housing for the catalytic converter. For example, since the openings in the sheet materials are predictable, a single converter housing design could be used to prevent the by-passing of polluting exhaust gases through the predictable openings and the housings can be easily reproduced in the quantity desired.

Figures 4A and 5A illustrate other embodiments of the tension relieved mounting article of the invention. The sheet material 22 of Figure 4A has two pairs of scores lines 24 in top surface 23 which corresponds to the smallest radius of curvature of the monolith. As shown in Figure 4B, when the sheet material 22 is wrapped around an oval shaped monolith 18, two predictable openings 26 in the area of highest tension are formed. Figures 5A and 5B show an embodiment of the mounting article of the invention having three pairs of score-lines 24 in the top surface 23 of the sheet material 22 and the resulting predictable openings 26 formed after the monolith 18 is wrapped in the sheet material. One of the advantages of a sheet material having a plurality or multiple score-lines in areas of high surface tension is that the length of sheet material required to wrap a given monolith is reduced by each additional score-line added to a surface of the sheet material.

Figures 6A and 6B show mounting article 20 comprising a sheet material 22 having a plurality of score-lines 24 over the top surface 23 of the sheet material. As shown in Figure 6B, the plurality of score-lines 24 provide predictable openings 26 in the surface of the sheet material. A sheet material having a plurality of score-

lines over the surface of the sheet material is preferred for round monoliths having relatively small diameters.

Figure 7A shows a mounting article 30 comprising a sheet material 22 having a plurality of score-lines 24 formed by attaching strips 32 of a mounting material onto a sheet material layer 34 such that the strips 32 are adjacent one another. The strips 32 are attached adjacent one another so to provide score-lines 24 in the surface of the sheet material 22. The score-lines provide predictable openings 26 in the surface of the sheet material after the sheet material is wrapped around a round monolith 18 as shown in Figure 7B. The strips 32 may be attached to the sheet material layer by stitching, staples, adhesives and the like. The width of the score-lines may be determined by the placement of the strips on a layer of the sheet material. Strips 32 and sheet material layer 34 may be made from the same materials as those described for sheet materials 22 below. It is also contemplated that the sheet material layer may also comprise strips of mounting material that are adhered to strips in a staggered fashion to provide alternating score lines in both surfaces of a mounting article.

Figures 8A and 8B illustrate a mounting article 20 of the invention comprising a sheet material 22 having score-lines 24 on both surfaces of the sheet material. The score-lines 24 on the inside surface 25 of sheet material 22 preferably have a greater width than corresponding score-lines 24 on the outer surface 23 of the sheet material 22 so to allow for compression of the inner surface of the sheet material.

As illustrated in Figures 9 and 10, the score-lines 24 may be provided in the surface of the sheet material 22 in any pattern as long as the openings created in the sheet material after wrapping a monolith are predictable and do not provide further undesirable cracking or propagation of the opening. The score-lines are preferably straight or linear in form.

The score-lines can be present across the width or the length of the sheet material, or both. The score-lines can extend across the entire width and/or length of the sheet material or the score-lines can extend across a portion of either or both length and width. For example, the score-lines may be made such that they are centered within the length or the width of the sheet material. The score-lines may

also begin at one edge and then extend partially across the length or width of the sheet material. Preferably, the score-lines extend across the entire width of the sheet material.

Sheet material 22 may be any resilient sheet that is useful for mounting monoliths, filter elements, or traps within a housing. The sheet material may comprise non-intumescent materials, intumescent materials or a combination thereof. The sheet material may be mutilayered in structure, for example, two or more relatively thin intumescent or non-intumescent sheet materials adhered or laminated together to form a uniform, thicker sheet material. Useful adhesives include web adhesives and hot melt adhesives. A preferred adhesive is a web adhesive.

Examples of useful non-intumescent sheet materials include those made from ceramic fibers. Useful ceramic fibers include alumina-boria-silica fibers, alumina-silica fibers, alumina-phosporous pentoxide fibers, zirconia-silica fibers, zirconia-alumina fibers, and alumina fibers. Commercially available fibers include those under the trademarks FIBERMAX, available from Unifrax, SAFFIL LD, available from ICI Chemicals and Polymers, ALCEN alumina fibers, available from Denka, and MAFTECH fibers, available from Mitsubishi.

The fibers are typically formed by blowing or spinning using methods known in the industry. The fibers are formed into a sheet by various known methods including blowing the fibers onto a collection screen as is practiced in the nonwoven industry. Non-intumescent sheet materials may also be made by wet-laid or papermaking techniques. Non-intumescent sheets made of ceramic fibers are generally compressed and held in the compressed state to facilitate handling during the canning process. Compression techniques include resin bonding, stitch bonding, or vacuum packing.

Preferably, sheet material 22 comprises a resilient, flexible intumescent sheet comprising from about 5 to about 65 percent by weight of unexpanded vermiculite particles or flakes, such flakes being either untreated or treated by being ion exchanged with an ammonia compound such as ammonium dihydrogen phosphate, ammonium carbonate, ammonium chloride, or other suitable ammonium compound as described in U.S. Patent No. 4,305,992 (Langer et al.),

incorporated herein by reference; from about 10 to about 60 percent by weight of inorganic fibers including aluminosilicate fibers, glass fibers, zirconia-silica, and crystalline alumina fibers; from about 3 to about 25 percent by weight of an organic binder, for example, natural rubber latices, styrene-butadiene latices, butadiene acrylonitrile latices, latices of acrylate or methacrylate polymers and copolymers and the like; and up to about 40 percent by weight of inorganic filler material such as expanded vermiculite, hollow glass microspheres , and bentonite and other clays and the like. Useful intumescent sheet materials also include those described in U.S. Patent No. 5,523,059 (Langer), incorporated by reference herein.

Further examples of useful intumescent sheet materials include those described in U.S. Patent Nos. 3,916,057 (Hatch et al.), 4,305,992 (Langer et al.), 4,385,135 (Langer et al.), 5,254,410 (Langer et al.), 4,865,818 (Merry et al.), 5,151,253 (Merry et al.), and 5,290,522 Rogers et al.), all of which are incorporated by reference herein. Useful commercially available intumescent mats and sheets include those sold under the INTERAM trademark by Minnesota Mining & Manufacturing Company of St. Paul, Minnesota.

Available single layer intumescent sheet materials typically range in thickness from about 0.5 mm to about 15 mm. If two intumescent sheets are attached together, by mechanical means such as adhesive, staples or stitches and the like, then the thickness of the sheet materials typically range from about 1 mm to about 30 mm. Preferably, the thickness of the sheet material used in the present invention ranges from about 0.8 mm to about 20 mm and more preferably from about 6 mm to about 20 mm.

The score-lines may be placed in or cut into either surface or both surfaces of the sheet material and are preferably placed into the surface of the intumescent sheet material which is adjacent to the can or casing of the catalytic converter, the top surface. The score-lines are also preferably placed into the surface of the intumescent sheet material such that they correspond to the minimum radius of curvature of the monolith. The only limitation to the depth of a score-line into the surface of the sheet material is such that the score-line does not go completely through the entire width of the sheet material or otherwise is cut to such a depth that when the sheet material is wrapped around the monolith and placed under

stress, the score-line does not tear or propagate completely through the sheet material.

On the other hand, the score-line should not be so shallow so that when the sheet material is wrapped around the monolith and placed under tension, that the score-line results in unpredictable tearing or propagating which results in an undesirable depth, width or direction of the score-line. The depth of the score-lines is also related to the radius of curvature of the monolith which is directly related to the amount of surface tension placed on the sheet. As the radius of curvature decreases, the amount of surface tension in the corresponding region of the sheet increases. The limit of the depth of the score-lines for any particular end use can easily be determined by one skilled in the art without undue experimentation.

Preferably, the depth of the score-line may range from about 20 to about 90 percent of the thickness of the sheet material. More preferably, the depth of the score-lines is about 50 percent of the thickness of the sheet material.

The width of the score-lines when the sheet material is flat is not limited as long as the resulting gap or opening in the surface of the sheet material is repeatable and predictable in depth and width when the sheet material is wrapped around a monolith. Useful cross-sectional shapes for score-lines include vertical line shaped, "V"-shaped, "U"-shaped, triangular shaped, and square shaped. Generally, the widths of the score-lines may be up to about 20 mm. Preferably, the width of the score-line ranges from 0 (die cut) to about 5 mm.

The distance between adjacent multiple score-lines will depend on the particular end use. Accordingly, the distance between score-lines should be such that the tension in the surface of the sheet is relieved without undesirable propagating or tearing of the score-line and which results in a predictable opening when the sheet material is wrapped around a monolith. Generally, the distance between adjacent score-lines ranges from about 1 mm to about 100 mm with a distance between adjacent multiple score-lines being from about 1mm to about 30 mm being preferred.

The score-lines may be formed or placed into the surface of the sheet material by any means known in the art. Useful score-line producing means

include cutting, such as die cutting and forming the score-lines, for example by attaching spaced strips to a layer of sheet material or by other forming means.

Preferably, the score-lines are cut into a surface of an intumescent or non-intumescent sheet material by any convenient cutting means, such as by a utility knife, a razor and the like. More preferably, the score-lines can be cut into the surface of the sheet material simultaneously when the sheet material is die cut from a large sheet (not shown) to a predetermined size and shape. Figure 11 shows die 40 having a base 42 and a cavity 44 defined by die perimeter 46. Within cavity 44 are two scoring die rules 48 and a foamed ejection material 50. Die perimeter 46 and scoring dies 48 are typically made of metal, such as steel or stainless steel, and the base can be any rigid substrate, such as wood, plastic or metal and the like.

The thickness or height of scoring die rules 48 corresponds to the desired depth of the resulting score-lines and is less than the height of the perimeter die. The various heights of the scoring dies and the perimeter die may be adjusted depending on the thickness of the particular sheet material being cut. Of course the length of the sheet material is determined by the circumference of the monolith to be wrapped. The sheet materials of the invention have a length such that the two ends of the wrapped sheet material meet without overlapping and have no visible gap between the ends.

In use, a sheet of intumescent or non-intumescent mounting material is placed on top of die 40, pressure is applied onto the sheet material from a die cutter (not shown) and a scored and die-cut mounting article may be easily removed from the die due to foamed and resilient ejection material 50.

In use, the scored sheet materials of the invention are disposed between the monolith and the housing in similar fashion for either a catalytic converter of a diesel particulate filter. This may be done by first wrapping the monolith with a mounting article of the invention making sure that the score-lines are positioned at the points of minimum or smallest radius of curvature of the monolith (if the monolith is a shape other than round), as shown in Figures 3-5, inserting the wrapped monolith into a housing, and then welding or otherwise closing the housing. Preferably, the sheet materials of the invention have an interlocking tab

27 and notch 29 as shown, for example, in Figure 3A to assure a gas seal despite minor variations in monolith circumference.

The score-lines of the invention provide an economical and simple means to relieve the surface tension in intumescent and non-intumescent sheet materials encountered during wrapping of monoliths. The sheet materials of the invention may be of any thickness with the score-lines having particular use and utility in thicker (greater than about 6 mm) and/or less flexible intumescent and non-intumescent sheet materials. The score-lines also offer the advantage of allowing for the use of shorter pieces of intumescent sheet material than would otherwise be required without the score-lines. This results in a more efficient use of raw materials and a lower cost of manufacture .

Objects and advantages of this invention are further illustrated by the following examples, but the particular materials and amounts thereof should not be construed to unduly limit this invention. All parts and percentages are by weight unless stated otherwise.

Examples

Examples 1-3 and Comparative Example C1

Two 685.8 mm by 685.8mm layers of intumescent sheet material (INTERAM brand Type 100 Mat, 3100 g/m2, available from Minnesota Mining & Manufacturing Company) were laminated together using a web adhesive to form a sheet material having a total thickness of about 9.8 mm. Four 100 mm by 500 mm sheets were cut using a utility knife. Example 1 was made by cutting about halfway through the thickness of the sheet material with a utility knife across the width of the sample intumescent sheet. Two score-lines corresponding to the small radii of the monolith were cut into the sample sheet material. Examples 2 and 3 were made as described above, except for having 2 and 3 score-lines (4 and 6 total), respectively, corresponding to each small radius of curvature of the monolith. Comparative example C1 was a 100 mm by 500 mm sheet material as described above without score-lines.

Each of Examples 1, 2, and 3 and the comparative example C1 were wrapped around a ceramic monolith having dimensions of 3.18 in (8 cm)(minor

axis) X 6.68 in (17 cm) (major axis) (from Corning, Corning, NY) to determine the actual length necessary to achieve a complete wrap of the monolith. A "complete wrap" of the monolith for purposes of the Examples means that the two ends of the wrapped sheet material meet without overlapping and have no visible gap between the ends.

The lengths needed for each sample to completely wrap the monolith were as follows:

Control (C1)	461 mm	no score-lines
Example 1	456 mm	2 score-lines
Example 2	455 mm	4 score-lines
Example 3	453 mm	6 score-lines

The above data demonstrate that the intumescent sheet materials of the invention require less intumescent sheet material to completely wrap a monolith than a sheet material wherein no surface tension is relieved.

Example 4

A scored sheet material of the invention was made using a die illustrated in Figure 11. The die had a die rule perimeter height (above the base) of 0.5 in (1.27 cm) and a scoring die rule height (above the base) of about 0.302 in (0.77 cm) and was made of steel. The width or gauge of the die perimeter and the scoring dies was about 0.042 in (1.07 mm) and 0.028 in (0.71 mm) respectively. The ejection material was a 0.375 in (0.95 cm) thick soft elastomeric material.

A sample of the laminated sheet material described above in Examples 1-3 was die cut with the die using a ROTOMATIC II brand die cutter, available from Ampak, Inc., Anderson, SC. The die cut and scored sheet material could be easily removed from the die without cracking or breaking. The scored sheet material was flexed by hand to simulate the wrapping of a monolith. The two score-lines formed openings in the sheet material which had uniform widths and depths without undesirable cracking or propagating.

Example 5 and Comparison Sample C2

Two INTERAM brand type 100 intumescent mats were laminated together with a web adhesive to form a sheet material having a basis weight of about 6200 g/m^2. The sheet material was cut into two approximately 97 mm X 400 mm sheet materials for wrapping a ceramic oval monolith having a major axis of 5 in (12.7 cm), minor axis of 2.5 in (6.35 cm) and a length of 4.37 in (11.1 cm). The monolith was initially wrapped with the sheet material for sizing and the excess length was cut away. The monolith was wrapped with the sized sheet material C2 (no score-lines) and random surface cracks appeared in the areas of smallest radius curvature (major axis).

Two score-lines were cut into the other 97 mm X 400 mm sheet material and were spaced such that each score-line would correspond to areas of smallest radius of curvature. The score-lines extended into the sheet material to a depth of about 50% of the thickness of the sheet material and extended across the total width of the sheet. The sheet material was cut to the appropriate length and the monolith was wrapped. Uniform openings in the areas of the score-lines were observed with no additional random surface cracking observable.

Example 6 and Comparative Example C3

Sheet materials were prepared as in Example 5 above except that the Example 6 sheet material had eight evenly spaced score-lines in its surface. Each of the score-lines extended completely across the width of the sheet. Each of the above sheet materials were wrapped around a round ceramic monolith having a diameter of 2.66 in (6.76 cm) and a length of 4 in (10.2 cm). A random crack in the surface of the comparison sheet material extended across the width of the sheet. The sheet material of Example 6 provided uniform openings in the area of the score-lines without any additional random cracking.

Example 7

A sheet of INTERAM brand Type 100 intumescent mounting sheet was cut into nine 4 in (10.2 cm) X 1 in (2.54 cm) strips. These strips were adhered (Case

Sealing Adhesive, Minnesota Mining and Manufacturing Company) to the surface of a 4 in (10.2 cm) X 9 in (22.9 cm) sheet of INTERAM brand Type 100 intumescent sheet material, the strips contacting one another. The sheet material was wrapped around the round monolith as in Example 5 such that the score-lines provided openings that faced away from the monolith. The openings were predictable and uniform. No additional random cracks were observed.